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ABSTRACT

This teaching guide is designed to help teachers develop lesson plans around nine chapters provided in the student textbook. Chapters focus on energy use, energy demand, energy supply, principles of electric power generation, today's generating options, future generating options, electricity storage and delivery, environmental concerns, and making energy decisions. The guide is not intended as a comprehensive step-by-step instructional aid; rather, its purpose is to suggest some general classroom procedures and activities. The guide presents a nine-part format related to each chapter, including a one- or two-sentence summary of the chapter contents, list of major topics, statement of the chapter's objective, list of key words, general questions for discussion that challenge students to think beyond the contents, suggestions for activities (including field trips and guest lectures), list of additional readings, list of films and audiovisual resources, and a short quiz. An answer key for the nine quizzes is also provided. (JN)

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Electricity

Today's Technologies, Tomorrow's Alternatives

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ELECTRICITY

TEACHER GUIDE

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Teacher's Guide
ELECTRICITY
Today's Technologies, Tomorrow's Alternatives

EPRI Electric Power Research Institute

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The Electric Power Research Institute (EPRI) was founded in 1972 by the nation's electric utilities to develop and manage a technology program for improving electric power production, distribution, and utilization.

EPRI is a nonprofit organization headquartered in Palo Alto, California. It is supported by voluntary contributions from both public and private utilities, and the results of its research are available to all.

The Institute's research is carried out in laboratories throughout the country—in private companies, in academic centers, in specialized research organizations, and in utilities themselves. The range of its work includes fossil and nuclear power plants, transmission and distribution technology, new forms of clean fuels, new energy sources such as solar and fusion, energy resources, and environmental problems connected with electric power technology.

Further information on EPRI and its research program is available from the Communications Division, EPRI, P.O. Box 10412, Palo Alto, California 94303.

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Introduction

Electricity is the fastest growing form of energy in the United States. Today, about one-third of our energy is converted into electricity before it is used. By the turn of the century, as much as half our total energy may be produced in the power plants of the nation's electric utilities. Whether this momentum toward electricity use will be sustained at a rational and adequate pace is an issue that demands full and immediate attention. And the technology of producing and delivering electricity cannot be separated from a discussion of how we get from today's forecasts to tomorrow's realities.

Electricity: Today's Technologies, Tomorrow's Alternatives is the product of the accumulated knowledge of the staff of the Electric Power Research Institute. It reflects the comments and suggestions of dozens of individuals from inside and outside the electric power industry. Our purpose is served if the book stimulates in the public a measure of technical awareness and curiosity so that the industry's energy decisions reflect the aspirations of an enlightened constituency.

This teacher's guide, which accompanies *Electricity*, is designed to help teachers develop lesson plans around the nine text chapters. The guide is not intended as a comprehensive step-by-step instructional aid; rather, its purpose is to suggest some general classroom procedures and activities. The guide presents a nine-part format for each chapter:

- A one- or two-sentence summary of the chapter contents
- A list of major topics
- A statement of the chapter's objective
- A list of key words
- General questions for discussion that challenge the students to think beyond the contents
- Suggestions for activities, including field trips and guest lectures
- Additional reading—selected entries from the text bibliography appropriate to a given chapter
- Films and audiovisual resources—selected entries from the text resources list appropriate to a given chapter
- A short quiz

Chapter 1

ENERGY USE

Chapter 1 describes forms of energy important in electric power generation and how people have used energy forms from prehistoric times to the present.

TOPICS

Forms of energy
Energy use through the ages
Energy use in modern society

OBJECTIVE

To define forms of energy and describe how these forms have been used throughout history.

KEY WORDS

chemical energy conversion current
electric energy energy heat energy
incandescence kinetic energy mechanical energy
nuclear energy potential energy radiant energy
technology voltage

QUESTIONS FOR DISCUSSION

1. Can you create electric current by touching the ends of a metal wire together? Why or why not?
2. Why did it take so long for new insights and the use of tools to spread?
3. How did the steam engine improve the standard of living?
4. How would we conduct our daily lives if we could not use electricity whenever we wanted?

ACTIVITIES

1. On a large poster, construct a time line (like the one in Figure 1–3) to scale and have the students fill in the dates of as many inventions and scientific discoveries as they can find. Discuss the effect of discoveries on subsequent breakthroughs.
2. The East Coast blackouts of 1965 and 1978 provide good examples of the effects of a power failure. Ask students to bring newspaper and magazine accounts of these events to class and discuss what might happen if there were a power failure in their area.

ADDITIONAL READING

Alder, Irving. *Electricity in Your Life.* New York: John Day, 1965.

Asimov, Isaac. "The Nightmare of Life Without Fuel." *Time,* April 1977.

Burke, James. *Connections.* Boston: Little, Brown, 1978.

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Kiefer, Irene. *Energy for America.* New York: Atheneum, 1979.

Trager, James. *The People's Chronology.* New York: Holt, Rinehart & Winston, 1979.

Wellman, William R. *Elementary Electricity.* New York: Van Nostrand Reinhold, 1971.

Wilson, Mitchell. *Energy.* Chicago: Time-Life Books, Life Science Library, 1963.

FILMS AND AUDIOVISUAL RESOURCES

"The Energy Experience." 16mm, color, 25 minutes. Free on loan. From Chevron U.S.A., Inc., Chevron Film Library, 6290 Sunset Boulevard, Hollywood, California 90028, (213) 463-1705.

"Energy—Finding the Way." 16mm, color, 14 minutes (13259). Free on loan. From Modern Talking Picture Service, Inc., Film Scheduling Center, 5000 Park Street North, St. Petersburg, Florida 33709, (813) 541-6661.

"Energy for the Future." 16mm/videocassette, color, 17 minutes (3348). Purchase price $245; rental fee $16. From Encyclopaedia Britannica Educational Corp., 425 North Michigan Avenue, Chicago, Illinois 60611, (312) 321-6800.

"Energy in Perspective." 16mm, color, 21 minutes (10344). Free on loan. From Modern Talking Picture Service, Inc., Film Scheduling Center, 5000 Park Street North, St. Petersburg, Florida 33709, (813) 541-6661.

"Energy Seekers." 16mm, color, 12 minutes (13754). Free on loan. From Modern Talking Picture Service, Inc., Film Scheduling Center, 5000 Park Street North, St. Petersburg, Florida 33709, (813) 541-6661.

"A Matter of Time." 16mm, color, 9 minutes. From Southern California Edison Company, Attn: Fred Mickelson, 2244 Walnut Grove Avenue, Rosemead, California 91770, (213) 572-1212.

"Power for a Nation." 16mm, color, 28 minutes. Free on loan. From U.S. Department of the Interior, Film Management Center, Water and Power Resource Service, P.O. Box 25007, DFC, Denver, Colorado 80225, (303) 234-3000.

EVALUATION

Match the energy form with its description.

____ 1. The energy of fast-moving molecules within a substance
____ 2. The flow of electrons
____ 3. The energy of an object in motion
____ 4. The energy contained in a substance's composition
____ 5. Stored energy
____ 6. Sunlight
____ 7. Fission or fusion in an atom's nucleus
____ 8. Force applied to an object, causing motion

a. electric energy
b. potential energy
c. nuclear energy
d. mechanical energy
e. kinetic energy
f. heat energy
g. radiant (light) energy
h. chemical energy

9. Name at least three kinds of energy used by early people.

10. How did the steam engine change manufacturing?

11. Name two types of energy used today that were unavailable to our ancestors.

Chapter 2

ENERGY DEMAND

Chapter 2 defines energy and electricity demand, explains their relationship to the economy, and shows why forecasting future demand is important. The chapter also describes the role of conservation in the way we use electricity.

TOPICS

Demand measurement
Energy and the economy
Demand forecasts
Energy demand and conservation

OBJECTIVE

To describe energy and electricity demand, their relationship to the economy, and the ways conservation can affect demand.

KEY WORDS

British thermal unit conservation
demand forecast economy electricity demand
energy demand gross national product kilowatt
kilowatthour price quad watt watthour

QUESTIONS FOR DISCUSSION

1. Why do we measure electricity demand separately from total energy demand?
2. How can the rate of electricity use increase if the rate of total energy use decreases?
3. What effect does price have on demand?
4. Why is it important to know how much energy we will need in the future?
5. How can we conserve our energy and still maintain economic growth and our standard of living?

ACTIVITIES

1. Invite a member of your local utility to talk to the class about local electricity demand: which sector uses the most electricity, how much an average household uses each month, how the utility forecasts future demand, etc.
2. Ask students to read their home electric meters for one week and bring the readings to class. Discuss which appliances and activities consume the most electricity and why.
3. Students can read the rating labels on home electrical equipment, count the number of lights (and wattages) in their homes, determine the amount of time lights and appliances are used, and "project" how much electricity they use at home. They can compare their guesses with their meter readings.

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Alder, Irving. *Electricity in Your Life.* New York: John Day, 1965.

The Farallones Institute. *Integral Urban House: Self-Reliant Living in the City.* San Francisco: Sierra Club Books, 1979.

Pringle, Laurence. *Energy: Power for People.* New York: Macmillan, 1975.

Sawhill, John C., ed. *Energy Conservation and Public Policy.* Englewood Cliffs, N.J.: Prentice-Hall, 1979.

Wilson, Mitchell. *Energy.* Chicago: Time-Life Books, Life Science Library, 1963.

Wolfe, Ralph. *Home Energy for the Eighties.* Charlotte, Vermont: Garden Way Assoc., 1979.

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"America's Changing Energy Story." Filmstrip with cassette, color, 48 frames, 7½ minutes (N81110). Purchase price $2.70. From American Gas Association, Order and Billing Department, 1515 Wilson Boulevard, Arlington, Virginia 22209, (703) 841-8661.

"A Case of Supply and Demand." 16mm, color, 17 minutes. Purchase price $200. From Research Reports Center, P.O. Box 50490, Palo Alto, California 94303, (415) 965-4081.

"Energy Alternatives." Filmstrip with cassette and teacher's guide, 56 frames (FS-385-D). Purchase price $25. From Crystal Productions, Box 12317, Aspen, Colorado 81612.

"The Energy Picture." 16mm, color, 27 minutes (15396). Free on loan. From Modern Talking Picture Service, Inc., Film Scheduling Center, 5000 Park Street North, St. Petersburg, Florida 33709, (813) 541-6661.

"Energy Update," "Energy: The American Experience," "Running on Empty: The Fuel Economy Challenge." From National Audiovisual Center, National Archives and Records Service, General Services Administration, Reference Section FF, Washington, D.C. 20409, (301) 763-1896.

EVALUATION

Write T in the blank provided if the statement is true: write F if the statement is false.

____ 1. The Btu measures electricity demand.

____ 2. The amount of energy it takes to generate electricity is included in total energy demand.

____ 3. A quad (one quadrillion Btu) is a measure of total energy.

____ 4. About half of all our energy is consumed by industry.

____ 5. Price has no effect on demand.

____ 6. Electricity use declined during the 1970s as people cut back their oil use.

____ 7. Demand forecasts are projections of how much energy and electricity we may need in the future.

____ 8. The aim of conservation should be to reduce the amount of energy we consume.

____ 9. Increased efficiency means getting more economic growth from what we put into the production of goods and services.

____ 10. Changes in technology that use more energy can help us conserve if they help us produce more goods.

Chapter 3

ENERGY SUPPLY

Chapter 3 describes our supply sources and outlines considerations that govern how much energy we obtain from them.

TOPICS

Resource use
Supply sources

OBJECTIVE

To teach students which sources supply our energy and the factors that affect how much energy we get from these sources.

KEY WORDS

availability coal environmental effects
fossil fuel geothermal power hydroelectric power
natural gas nuclear power oil price
renewable resources resource supply
technology uranium

QUESTIONS FOR DISCUSSION

1. Do the four factors that affect resource use affect each other? Explain your answer.
2. Of the four factors, which one is most affected by world politics?
3. Why will coal be an important fuel in the future?
4. What are the obstacles to the use of renewable resources? How can these problems be overcome?
5. Why will generation mix change in the next 20 years?

ACTIVITIES

1. Invite a member of your local utility to discuss with the class the utility's generation mix, where it obtains its supplies, what its long-term future supplies are likely to be, etc.
2. Have the students make a large map of the United States and indicate areas of fuel sources, such as coal and uranium. The class can make other maps, such as one showing regions where renewable resources are most abundant.
3. Ask students to select a fuel source and write a report on its current contribution to our energy supply and what its future use may be and why.

ADDITIONAL READING

"Energy—A Special Report." *National Geographic,* February 1981.

Energy in Transition 1985–2010: Final Report of the Committee on Nuclear and Alternative Energy Systems, National Research Council. For the National Academy of Sciences. San Francisco: W. H. Freeman, 1980.

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Lihach, Nadine. "Coal Supply: New Strategy for an Old Game." *EPRI Journal,* October 1980, pp. 6–12. See also editorial by René Malès, pp. 2–3.

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"America's Changing Energy Story." Filmstrip with cassette, color, 48 frames, 7½ minutes (N81110). Purchase price $2.70. From American Gas Association, Order and Billing Department, 1515 Wilson Boulevard, Arlington, Virginia 22209, (703) 841-8661.

"The Breeder." 16mm/videocassette, color, 23 minutes. Purchase price $350; rental fee $35/day. From Stuart Finley, Inc., 3428 Mansfield Road, Falls Church, Virginia 22041, (703) 820-7700.

"A Case of Supply and Demand." 16mm, color, 17 minutes. Purchase price $200. From Research Reports Center, P.O. Box 50490, Palo Alto, California 94303, (415) 965-4081.

"Coal: An American Asset." 16mm, color, 28 minutes. Free on loan. From National Coal Association, 1130 17th Street N.W., Washington, D.C. 20036, (202) 628-4322.

"Coal—An Answer to the Energy Crisis." 16mm, color, 13 minutes (VIII-4). Free on loan. From Ashland Oil, Inc., Attn: Audiovisuals Coordinator, P.O. Box 391, Ashland, Kentucky 41101, (606) 329-3846.

"Coal: The Other Energy." 16mm, color, 15 minutes (526). Free on loan. From U.S. Department of Energy, DOE Film Library, P.O. Box 62, Oak Ridge, Tennessee 37830, (615) 576-1285.

"The Vital Search." 16mm, color, 18 minutes (12872). Free on loan. From Modern Talking Picture Service, Inc., Film Scheduling Center, 5000 Park Street North, St. Petersburg, Florida 33709, (813) 541-6661.

EVALUATION

Write the letter of the item that best fits the description.

____ 1. Considerations that govern resource use
   a. technology
   b. price
   c. availability
   d. environmental effects
   e. all of the above

____ 2. A resource, once inexpensive and plentiful, that is becoming increasingly expensive and hard to obtain
   a. natural gas
   b. oil
   c. nuclear
   d. geothermal dry steam
   e. coal

____ 3. The most abundant fossil fuel resource in the United States
   a. oil
   b. uranium
   c. solar
   d. coal
   e. hydroelectric

____ 4. Two obstacles to the use of renewable resources
   a. cost and technology
   b. technology and availability
   c. environmental effects and technology
   d. availability and environmental effects
   e. none of the above

____ 5. A renewable resource that currently contributes to our energy supply
   a. nuclear
   b. biomass
   c. photovoltaic
   d. fusion
   e. hydroelectric

____ 6. One of the least expensive ways to generate electric power
   a. nuclear
   b. coal
   c. oil
   d. renewables
   e. natural gas

____ 7. A domestic fuel used in nuclear fission
   a. coal
   b. oil
   c. uranium
   d. hydroelectric
   e. tritium

____ 8. One problem with coal use
   a. price
   b. licensing delays
   c. availability
   d. environmental effects
   e. none of the above

____ 9. The proportion of fuels used to produce electricity
   a. supply source
   b. coal and nuclear
   c. generation mix
   d. resource use
   e. none of the above

Chapter 4

PRINCIPLES OF ELECTRIC POWER GENERATION

Chapter 4 explains the need for energy conversion, the conversion of mechanical energy into electric energy, and the control of energy loss in the conversion process. The chapter also describes utility power generation.

TOPICS

The need for conversion
Conversion efficiency
Controlling energy loss
Utility power generation

OBJECTIVE

To describe how energy forms are converted into electric energy and how the nation's utilities provide electric power to their customers.

KEY WORDS

baseload cogeneration conversion economic dispatch efficiency generator intermediate load lead time load load factor load management peak load rate base reserve reserve margin superconductivity turbine working fluid

QUESTIONS FOR DISCUSSION

1. Why is it necessary to convert energy from one form to another for certain tasks?
2. Why is it necessary to have a working fluid in gas, steam, or water turbines?
3. What are some ways energy loss is controlled in electric power generation?
4. How does a utility meet varying system load?
5. What are the costs of providing electricity?

ACTIVITIES

1. Arrange a tour of one of your utility's generating plants.
2. Invite a member of your local utility to discuss the utility's load characteristics and load management techniques.

ADDITIONAL READING

Hopkinson, Jenny. "Electricity Generation Near Absolute Zero." *EPRI Journal*, March 1981, pp. 6–11. See also editorial by John J. Dougherty, pp. 2–3.

Wayne, Mary. "Plugging Cogenerators Into the Grid." *EPRI Journal*, July/August 1981, pp. 6–14. See also editorial by Robert L. Mauro, pp. 2–3.

Weiss, Harvey. *Motors and Engines and How They Work*. New York: Thomas Y. Crowell, 1969.

Wellman, William R. *Elementary Electricity*. New York: Van Nostrand Reinhold, 1971.

FILMS AND AUDIOVISUAL RESOURCES

"An Electric Talking Picture." 16mm, color, 13 minutes. Purchase price $250. From Consolidated Edison Company of New York, Inc., Attn: Russell Holt, 4 Irving Place, New York, New York 10003.

"Exploring Electric Energy." 16mm, color, 18 minutes. Purchase price $175. From Kevin Donovan Films, 44 Treat Road, Box 309, Glastonbury, Connecticut 06033, (203) 633-9331.

"The World Beyond Your Light Switch." 16mm, color, 28 minutes. Free on loan. From Bonneville Power Administration, U.S. Department of Energy, Information Office, P.O. Box 3621, Portland, Oregon 97208, (503) 234-3361.

EVALUATION

Fill in the blank with the appropriate word(s).

1. The _____ is a device for converting mechanical energy to electric energy.

2. The device that provides the mechanical energy that turns the shaft in a generator is called a _____.

3. The kinetic energy in water, gas, and steam turbines is provided by the _____.

4. The property of metals and alloys, when they are cold enough, that allows an essentially loss-free flow of electric current is called _____.

5. The sum of all its customers' demand is the utility's _____.

6. _____ is the procedure the dispatcher will use in calling different generating units into service.

7. _____ plants supply electricity around the clock.

8. An excess of capacity beyond actual load is called _____.

9. The total value of a utility's equipment is its _____.

10. The ratio of average load to peak load, expressed as a percentage, is called a utility's _____.

Chapter 5

TODAY'S GENERATING OPTIONS

Chapter 5 describes the systems used to generate today's electricity and their fuel sources.

TOPICS

Power from fossil fuels
Nuclear power
Hydroelectric power
Dry steam geothermal power

OBJECTIVE

To teach students the ways in which electricity is generated today, the fuel sources used for each type of generating system, and the advantages and disadvantages of using each system.

KEY WORDS

boiler boiling water reactor bottoming cycle
chain reaction combined cycle control rod
coolant dry steam fossil fuel
geothermal power head hydroelectric power
isotope light water reactor magma
moderator nuclear fission nuclear fuel cycle
plutonium pressurized water reactor
topping cycle uranium

QUESTIONS FOR DISCUSSION

1. In what ways do steam and gas turbines differ? What are the advantages and disadvantages of using each system?
2. What are the prospects for future fossil fuel use?
3. Why is nuclear fission described as a chain reaction? Why is this reaction important for the nuclear fuel cycle?
4. What are the advantages and disadvantages of hydroelectric power?
5. How does dry steam geothermal power work?

ACTIVITIES

1. Arrange a tour of one of your utility's generating plants.
2. Have students locate dams that produce hydroelectric power on a large map of the United States and indicate the head of each dam. Each student can be assigned a state. States that have extensive dam systems can be divided among several students.
3. Ask a physics or chemistry teacher to give a short lecture on the basics of atomic structure.

ADDITIONAL READING

Asimov, Isaac. *How Did We Find Out About Nuclear Power?* New York: Walker, 1976.

Burke, James. *Connections.* Boston: Little, Brown, 1978.

Comar, Cyril L. "Plutonium: Facts and Inferences." *EPRI Journal,* November 1976, pp. 20–24.

Kenton, John. "The Birth and Early History of Nuclear Power." *EPRI Journal,* July/August 1978, pp. 6–15. See also editorial by Milton Levenson, pp. 2–3.

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Teller, Edward. *Energy From Heaven and Earth*. San Francisco: W. H. Freeman, 1979.

Weaver, Kenneth F. "The Promise and Peril of Nuclear Energy." *National Geographic*, April 1979, pp. 459–493.

FILMS AND AUDIOVISUAL RESOURCES

"America's Changing Energy Story." Filmstrip with cassette, color, 48 frames, 7½ minutes (N81110). Purchase price $2.70. From American Gas Association, Order and Billing Department, 1515 Wilson Boulevard, Arlington, Virginia 22209, (703) 841-8661.

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"Energy for the Future." 16mm/videocassette, color, 17 minutes (3348). Purchase price $245; rental fee $16. From Encyclopaedia Britannica Educational Corp., 425 North Michigan Avenue, Chicago, Illinois 60611, (312) 321-6800.

"Nuclear Energy." Filmstrip with cassette and teacher's guide, 60 frames (FS-384-D). Purchase price $25. From Crystal Productions, Box 12317, Aspen, Colorado 81612.

"Nuclear Power Inside and Out." Slides, color, 20 frames. Purchase price $60. From Atomic Industrial Forum, Inc., 7101 Wisconsin Avenue, Washington, D.C. 20014, (301) 654-9260.

"What Happened at Three Mile Island?" Videotape, color, 15 minutes. Purchase price $50. From Atomic Industrial Forum, Inc., 7101 Wisconsin Avenue, Washington, D.C. 20014, (301) 654-9260.

"Why Nuclear Energy?" Slides, color, 130 frames. Purchase price $100. From Atomic Industrial Forum, Inc., 7101 Wisconsin Avenue, Washington, D.C. 20014, (301) 654-9260.

EVALUATION

Match the appropriate term with the description. (*Hint:* Not all lettered terms will be used.)

____ 1. A large vessel enclosed by metal tubing

____ 2. A gas turbine and a steam turbine working together for improved efficiency

____ 3. Fuel used in nuclear electricity generation

____ 4. Slows down neutrons emitted during fission

____ 5. Carries the heat of fuel rods to another part of the power plant

____ 6. Nuclear fuel materials from mine to waste disposal

____ 7. Nuclear power reactor currently in commercial use in the United States

____ 8. The vertical distance between water level in a reservoir and the turbine in a dam

____ 9. Power from heat beneath the earth's surface

____ 10. Uses kinetic energy of moving water

a. moderator
b. uranium
c. boiler
d. plutonium
e. combined cycle
f. light water reactor
g. hydroelectric power
h. nuclear fuel cycle
i. geothermal power
j. head
k. coolant

Chapter 6

FUTURE GENERATING OPTIONS

Chapter 6 describes technologies that have great potential for future electricity generation.

TOPICS

Clean coal combustion
Solar power
Wind power
Ocean power
Biomass conversion
Emerging geothermal options
Fuel cells
Magnetohydrodynamics
Breeder reactors
Nuclear fusion
The technology time scale

OBJECTIVE

To describe the ways in which electricity may be generated in the future.

KEY WORDS

anaerobic fermentation biomass blanket breeder catalyst central receiver system chemical reduction core dispersed system electrolyte flashed steam fluidized bed fuel cell gasification geopressured zone geothermal energy heliostat hydrogenation inertial confinement ionization liquefaction magnetic confinement magnetohydrodynamics nuclear fusion ocean-thermal conversion photovoltaic cell photovoltaic conversion plasma plutonium power tower pyrolysis semiconductor slurry solar power solar-thermal conversion storage thermophotovoltaic converter tidal energy conversion tokamak torus wave energy conversion wind energy conversion

QUESTIONS FOR DISCUSSION

1. What three coal technologies may provide future coal-based fuels and how do they work?
2. In what ways do dispersed solar systems and central receivers differ?
3. How does photovoltaic conversion generate electric power directly from sunlight?
4. How does the thermophotovoltaic converter contribute to solar cell use?
5. What are some obstacles to wind turbine use?
6. Describe ocean-thermal conversion.
7. What is the difference between wave and tidal energy conversion?
8. Name two major biomass conversion schemes and describe how they would contribute to our energy supply.
9. What three emerging technologies may contribute to geothermal power and how do they work?
10. Why is "power sandwich" a good description of a fuel cell?
11. How does a magnetohydrodynamic generator differ from a conventional generator?
12. How do the light water reactor and the breeder reactor differ?
13. How does the liquid metal fast breeder reactor work?
14. What is the difference between nuclear fission and nuclear fusion?
15. How do magnetic confinement and inertial confinement differ?

ADDITIONAL READING

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Teller, Edward. *Energy From Heaven and Earth*. San Francisco: W. H. Freeman, 1979.

Thomsen, Dietrick E. "Bumps in the Torus." *Science News*, January 10, 1981, p. 27.

Watts, Alan. *Instant Wind Forecasting*. New York: Dodd, Mead, 1975.

FILMS AND AUDIOVISUAL RESOURCES

"The Electric Story: Wind Power." 16mm, color, 18 minutes. Purchase price $200. From Research Reports Center, P.O. Box 50490, Palo Alto, California 94303, (415) 965-4081.

"Fusion—Energy for the Future." 16mm, color, 13 minutes (VIII-6). Free on loan. From Ashland Oil, Inc., Attn: Audiovisuals Coordinator, P.O. Box 391, Ashland, Kentucky 41101, (606) 329-3846.

"Fusion—The Ultimate Fire." 16mm, color, 14½ minutes (532). Free on loan. From U.S. Department of Energy, DOE Film Library, P.O. Box 62, Oak Ridge, Tennessee 37830, (615) 576-1285.

"Geothermal: Energy From the Earth." 16mm, color, 25 minutes (11917). Free on loan. From Modern Talking Picture Service, Inc., Film Scheduling Center, 5000 Park Street North, St. Petersburg, Florida 33709, (813) 541-6661.

"Gusts of Power." 16mm, color, 14 minutes (535). Free on loan. From U.S. Department of Energy, DOE Film Library, P.O. Box 62, Oak Ridge, Tennessee 37830, (615) 576-1285.

"Nuclear Energy." Filmstrip with cassette and teacher's guide, 60 frames (FS-348-D). Purchase price $25. From Crystal Productions, Box 12317, Aspen, Colorado 81612.

"Harness the Wind." 16mm, color, 12 minutes. Purchase price $200; rental fee $20. From Bullfrog Films, Oley, Pennsylvania 19547, (215) 779-8226.

"Wind—An Energy Alternative." 16mm, color, 12 minutes (544). Free on loan. From U.S. Department of Energy, DOE Film Library, P.O. Box 62, Oak Ridge, Tennessee 37830, (615) 576-1285.

"Wind Energy." Filmstrip with cassette and teacher's guide, 80 frames (FS-380). Purchase price $26. From Crystal Productions, Box 12317, Aspen, Colorado 81612.

EVALUATION

Fill in the blank with the appropriate word(s).

1. The process in which coal changes from solid to liquid form is called _____.

2. _____ is a method of producing a clean, burnable gas from coal.

3. A concentrated suspension of crushed limestone particles in a flow of hot gas is called a _____.

4. The central receiver system is also known as the _____.

5. _____ is a conversion process that generates electric power directly from sunlight rather than using the sun's heat.

6. A solar cell variation with vastly improved efficiency is the _____.

7. A _____ does not require a mechanism to turn the rotor into the wind.

8. Three ocean power technologies are _____, _____, and _____.

9. _____ is organic material that can provide heat.

10. Three municipal solid waste technologies are _____, _____, and _____.

11. Reservoirs trapped in formations of impermeable shale are referred to as _____.

12. _____ can convert the chemical energy of fuels directly into electricity.

13. A process that uses electrically conductive gas instead of wire to produce electricity is called _____.

14. A _____ is a reactor that can produce more fissionable material than it consumes.

15. The most advanced magnetic confinement fusion technology is the _____.

16. _____ is a fusion process that uses laser or particle beams.

Chapter 7

ELECTRICITY STORAGE AND DELIVERY

Chapter 7 describes how electricity is transmitted, distributed, and stored.

TOPICS

How storage works
The transmission and distribution system
Underground versus overhead
Current transmission

OBJECTIVE

To explain how electricity is transmitted and distributed and to describe technologies for possible storage.

KEY WORDS

alternating current battery
compressed air storage conductor corona
damper direct current distribution
electrolysis electromagnet flywheel
galloping galloping detuner grid insulation
pumped hydro storage right-of-way
step-down transformer storage substation
superconductivity thermal storage transformer
transmission

QUESTIONS FOR DISCUSSION

1. What are some of the problems associated with storing large amounts of electricity?
2. How do transmission and distribution differ?
3. Is underground transmission better than overhead? Explain your answer.
4. What are the components of the transmission and distribution system and how do they work?
5. Why is direct current technology reemerging?

ACTIVITIES

1. Arrange to tour a substation of your local utility.
2. Students can make a small electromagnet in class. Each student will need a large iron nail or spike, a few feet of wire, a flashlight battery, and some small metal objects in a range of sizes and weights.

Directions: Wrap the wire around the nail or spike 20–25 times and connect the ends of the wire to the flashlight battery. The nail becomes an electromagnet that can pick up small metal objects. When the battery is disconnected, the nail loses its magnetic force. The number of turns the wire makes around the nail determines the strength of the magnetic force. Students can experiment with the number of turns and the amount of force.

3. Invite a member of your local utility to discuss with the class the utility grid system. The students can make a map of the utility service area and draw the grid on the map.

ADDITIONAL READING

Catron, Jack. "Putting Baseload to Work on the Night Shift." *EPRI Journal*, April 1980, pp. 6–13. See also editorial by Thomas R. Schneider, pp. 2–3.

Dunsheath, Percy. *Giants of Electricity*. New York: Thomas Y. Crowell, 1967.

Hopkinson, Jenny. "The New Batteries." *EPRI Journal*, October 1981, pp. 6–13. See also editorial by Arnold Fickett, pp. 2–3.

Wellman, William R. *Elementary Electricity*. New York: Van Nostrand Reinhold, 1971.

FILMS AND AUDIOVISUAL RESOURCES

"Electric Energy." 35mm slides with cassette, color, 155 slides, 15 minutes. Purchase price $60. From American Association for Vocational Instructional Materials, Engineering Center, Athens, Georgia 30602, (404) 542-2586.

"Electricity—The Way It Works." 16mm, color, 16 minutes. Purchase price $275. From Screen News Digest, Attn: Martin Kendrick, 235 East 45th Street, New York, New York 10017, (212) 682-7690.

"Electric Transmission and the Environmental Alternative." 16mm, color, 12 minutes. Free on loan. From Modern Talking Picture Service, Film Scheduling Center, 5000 Park Street North, St. Petersburg, Florida 33709, (813) 541-6661.

"Intertie." 16mm, color, 28 minutes. Free on loan. From Bonneville Power Administration, U.S. Department of Energy, Information Office, P.O. Box 3621, Portland, Oregon 97208, (503) 234-3361.

"Saving Tomorrow's Resources." 16mm, color, 18 minutes. Free on loan. From Bonneville Power Administration, U.S. Department of Energy, Information Office, P.O. Box 3621, Portland, Oregon 97208, (503) 234-3361.

"The World Beyond Your Light Switch." 16mm, color, 28 minutes. Free on loan. From Bonneville Power Administration, U.S. Department of Energy, Information Office, P.O. Box 3621, Portland, Oregon 97208, (503) 234-3361.

EVALUATION

Write T in the blank provided if the statement is true; write F if the statement is false.

____ 1. The battery works by converting chemical energy into electricity.

____ 2. When electricity is applied to ordinary water, the water decomposes into hydrogen and oxygen.

____ 3. An electromagnet is an iron cylinder wound with conducting wires that carry electricity.

____ 4. A flywheel stores energy when the wheel is set to rotating.

____ 5. The distribution system carries bulk electric energy from the generator to the substation.

____ 6. The transmission system is the whole interlocking system of electricity delivery.

____ 7. Conductors are the wires through which electricity flows.

____ 8. Substations transfer all power from generator to customer.

____ 9. Overheating and corrosion are the two greatest problems with underground cables.

____ 10. In the United States, most electricity is generated and consumed in ac form.

Chapter 8

ENVIRONMENTAL CONCERNS

Chapter 8 discusses the environmental effects of electricity generation technologies and methods to control these effects.

TOPICS

Balancing benefits and risks
Air quality
Solid waste management
Water quality
High voltage
Radiation
Effects of other technologies
Pollution control costs
Environmental legislation

OBJECTIVE

To describe the environmental effects of various electricity generation technologies and the methods of controlling adverse effects.

KEY WORDS

acidic precipitation aerosols ash baghouse calcine carbon dioxide chemical contamination control technology forcing cooling system electrostatic precipitator emission standards environment environmental effects fabric filter fly ash greenhouse effect high voltage leaching millirem nitrogen oxides particulates pollution radiation reactor year rem scrubbing sludge sulfur oxides thermal pollution visibility

QUESTIONS FOR DISCUSSION

1. What air pollutants are released during coal combustion and how are they controlled?
2. How does the utility industry manage solid waste?
3. How does electricity generation affect water quality?
4. Describe radiation waste disposal.
5. Should we remove as much pollution from a process as possible regardless of cost? Why or why not?

ACTIVITIES

1. Invite a member of your local utility to discuss various control technologies used by the utility.
2. The class can experiment with the effect of air pollution on nylon.

   Directions: In the center of a 1-foot-square piece of cardboard cut a square 6 inches by 6 inches. Cut an 8-inch-square piece of nylon from a nylon stocking. Cut carefully and brush the edges with clear nail polish to keep the nylon from running. Make a slit in each corner of the cardboard and work the ends of the nylon through, taking care not to stretch the nylon too tight. Examine the nylon carefully to note its condition and place outside where the sample will not be disturbed. Inspect it once a week. Students can do this experiment individually and compare their samples after several weeks.
3. Invite an environmentalist to the class to discuss local and state environmental issues.

ADDITIONAL READING

Hopkinson, Jenny. "Protecting Fish From Cooling-System Effects." *EPRI Journal*, December 1980, pp. 20–23.

Lihach, Nadine. "The Continuing Disposal of Coal Ash." *EPRI Journal*, March 1980, pp. 18–19.

Mawson, Colin. *The Story of Radioactivity*. Englewood Cliffs, N.J.: Prentice-Hall, 1969.

Nesbit, William. "The Upsurge in Baghouse Development." *EPRI Journal*, November 1980, pp. 14–20.

FILMS AND AUDIOVISUAL RESOURCES

"Air Is for Breathing." 16mm/videocassette, color, 29 minutes. Free on loan. From Shell Oil Company Film Library, 1433 Sadlier Circle West Drive, Indianapolis, Indiana 46239, (317) 872-7440.

"Black Diamonds—Green Pastures." 16mm, color, 15 minutes. Free on loan. From Science and Education Administration, U.S. Department of Agriculture, 5142 South Building, Washington, D.C. 20250, (202) 447-3987.

"Cooling Waters." 16mm, color, 26 minutes. Free on loan. From U.S. Department of Energy, DOE Film Library, P.O. Box 62, Oak Ridge, Tennessee 37830, (615) 576-1285.

"Energy Consequences." 16mm/videocassette, color, 20 minutes. Purchase price $400; rental fee $40/day. From Stuart Finley, Inc., 3428 Mansfield Road, Falls Church, Virginia 22041, (703) 820-7700.

"Energy vs. Ecology." 16mm, color, 28 minutes (30031). Free on loan. From Modern Talking Pictures, Film Scheduling Center, 5000 Park Street North, St. Petersburg, Florida 33709, (813) 541-6661.

EVALUATION

Write the letter of the item that best fits the description.

____ 1. Coal combustion by-products
   a. sulfur oxides, radiation, calcine, carbon dioxide
   b. particulates, fabric filters, nitrogen oxides, radiation
   c. thermal pollution, radiation, sulfur oxides, chemical contamination
   d. sulfur oxides, nitrogen oxides, particulates, carbon dioxide
   e. none of the above

____ 2. A technology for controlling sulfur oxides
   a. stack gas scrubbing
   b. baghouse
   c. aerosols
   d. electrostatic precipitator
   e. none of the above

____ 3. Electrostatic precipitators are used to control
   a. nitrogen oxides
   b. sulfur oxides
   c. carbon dioxide
   d. radiation
   e. particulates

____ 4. The greenhouse effect results from emission of
   a. carbon dioxide
   b. nitrogen oxides
   c. sulfur oxides
   d. particulates
   e. radiation

____ 5. One way in which generation can affect water quality
   a. radiation
   b. carbon dioxide
   c. thermal pollution
   d. sulfur oxides
   e. none of the above

____ 6. A form of radiation that can disrupt vital body functions
   a. rem
   b. ionizing
   c. nonionizing
   d. calcine
   e. none of the above

____ 7. A unit of radiation
   a. voltage
   b. rem
   c. current
   d. calcine
   e. none of the above

____ 8. One reactor year
   a. the operation of one reactor for one year
   b. the operation of eight reactors for eight years
   c. the operation of all the reactors in service for one year
   d. all of the above
   e. none of the above

____ 9. A fine powder of radioactive waste
   a. rem
   b. nonionizing radiation
   c. millirem
   d. calcine
   e. none of the above

____ 10. Legal limits on the amounts of substances that a given source can release
   a. EPA
   b. HEW
   c. emission standards
   d. control technology forcing
   e. none of the above

Chapter 9

MAKING ENERGY DECISIONS

Chapter 9 discusses the problems of making energy policy decisions.

TOPICS

The uncertainty factor
Coping with uncertainty

OBJECTIVE

To teach students the need to look ahead and consider the long-range consequences of today's energy decisions.

KEY WORDS

conservation cost electricity demand
energy demand flexibility outage
overcapacity public policy supply
technology uncertainty undercapacity

QUESTIONS FOR DISCUSSION

1. What are some factors that help create uncertainty in energy decision making?
2. What are some ways of coping with uncertainty?
3. How does public policy affect decision making?
4. Compare the consequences of overcapacity and undercapacity. Which one would have the lesser effect on our daily lives? Explain your answer.
5. What are some of the questions we must ask to make sensible decisions about the nation's energy future? Can you provide some answers?

ACTIVITIES

1. Invite a member of your local utility to discuss with the class the ways in which the utility plans to meet future demand.
2. Ask the students to debate the following statement: The consequences of overcapacity are less costly than those of undercapacity.

ADDITIONAL READING

Hopkinson, Jenny. "Models: A Resource for the Decision Maker." *EPRI Journal*, October 1980, pp. 13–16.

Rudman, R. L., and C. G. Whipple. "Time Lag of Energy Innovation." *EPRI Journal*, April 1980, pp. 14–20.

Sawhill, John C., ed. *Energy Conservation and Public Policy*. Englewood Cliffs, N.J.: Prentice-Hall, 1979.

Starr, Chauncey. "Choosing Our Energy Future." *EPRI Journal*, September 1980, pp. 6–11.

FILMS AND AUDIOVISUAL RESOURCES

"Energy Management for the Future." 16mm, color, 24 minutes. Free on loan. From Bonneville Power Administration, U.S. Department of Energy, Information Office, P.O. Box 3621, Portland, Oregon 97208, (503) 234-3361.

"Rethinking Tomorrow." 16mm, color, 28 minutes (546). Free on loan. From U.S. Department of Energy, DOE Film Library, P.O. Box 62, Oak Ridge, Tennessee 37830, (615) 576-1285.

EVALUATION

Write T in the blank provided if the statement is true; write F if the statement is false.

____ 1. Fuel prices affect energy demand.

____ 2. Utility costs are fixed and certain.

____ 3. The potential for technological growth and innovation makes decision making easy.

____ 4. Public policy affects future energy development.

____ 5. Undercapacity could result in a drop in production of goods and an increase in prices.

____ 6. Timing is critical in energy planning.

____ 7. If the design phase of a particular plant has been completed and the energy demand forecast drops, the plant need not be built.

____ 8. Utilities have to plan around uncertainty so that they can respond to swift changes in supply and demand.

____ 9. Outage costs are unimportant.

____ 10. It does not take much time to correct undercapacity if demand soars.

ANSWER KEY TO EVALUATIONS

Chapter 1 Energy Use

1. f
2. a
3. e
4. h
5. b
6. g
7. c
8. d
9. mechanical, heat, radiant (light), chemical, kinetic
10. The steam engine made it possible to mechanize many types of machines, which made manufacturing faster and more efficient. More commodities could be produced.
11. electric, nuclear

Chapter 2 Energy Demand

1. F
2. T
3. T
4. F
5. F
6. F
7. T
8. F
9. T
10. T

Chapter 3 Energy Supply

1. e
2. b
3. d
4. a
5. e
6. a
7. c
8. d
9. c

Chapter 4 Principles of Electric Power Generation

1. electric generator
2. turbine
3. working fluid
4. superconductivity
5. load
6. Economic dispatch
7. Baseload
8. reserve
9. rate base
10. load factor

Chapter 5 Today's Generating Options

1. c
2. e
3. b
4. a
5. k
6. h
7. f
8. j
9. i
10. g

Chapter 6 Future Generating Options

1. liquefaction
2. Gasification
3. fluidized bed
4. power tower
5. Photovoltaic conversion
6. thermophotovoltaic converter
7. vertical-axis turbine
8. ocean-thermal conversion, wave energy conversion, tidal energy conversion
9. Biomass
10. direct burning, chemical conversion, solid fuel pellets
11. geopressured zones
12. Fuel cells
13. magnetohydrodynamics
14. breeder
15. tokamak
16. Inertial confinement

Chapter 7 Electricity Storage and Delivery

1. T
2. T
3. T
4. T
5. F
6. F
7. T
8. T
9. T
10. T

Chapter 8 Environmental Concerns

1. d
2. a
3. e
4. a
5. c
6. b
7. b
8. a
9. d
10. c

Chapter 9 Making Energy Decisions

1. T
2. F
3. F
4. T
5. T
6. T
7. T
8. T
9. F
10. F